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Effect of organic sources of nitrogen on quality and yield of Indian mustard under sodic water irrigation

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Abstract

The groundwater in arid, and semi-arid regions used as a chief source of irrigation is generally saline/sodic,. The continuous use of such water for irrigation creates salinity or sodicity in the soil. To explore the potential of using sodic groundwater for mustard cultivation, an experiment was conducted to study the mitigation effect of organic sources of nitrogen under sodic water irrigation. The experiment comprising 24 treatment combination replicated three times, was laid out in split plot design with four treatment of sodic water (6 SAR, 10 SAR, 20 SAR, 30 SAR) and six treatment of sources of nitrogen (control, 125% RDN* through urea, 75% RDN* through urea + 50% RDN through FYM, 75% RDN through urea + 50% RDN through VC, 50% RDN through urea + 75% RDN through FYM, 50% RDN through urea + 75% RDN through VC). Results revealed that the application of 50% RDN through urea +75% RDN through VC (M_5) is a better choice for mitigating adverse effect of SAR rich water on quality, and yield of mustard as the magnitude of adverse effects on quality, and yield of mustard was minimum under the application of 50% RDN through urea +75% RDN through VC (M_5).Thus sodic groundwater could be a good source to exploit for supplemental irrigation through use of technology, and inputs.

Key words: *Indian mustard, nitrogen, organic sources, sodic water irrigation*

Introduction

Salt affected soils are an important ecological entity in the landscape of any arid, and semi-arid region. Shortage of good quality water forced the farmers to use saline/ sodic ground water as a chief source of irrigation which resulted in aggravated problem of salt affected soils. A total area of 6.7 Mha of salt affected soils is estimated at the country scale. Out of 6.7 Mha, saline, and sadic soils cover 2.9 Mha, and 3.7 Mha, respectively (MandaI *et al.*, 2010). The ground water of north-western Rajasthan is typical water with problem of high sodium adsorption ratio (SAR) flanked with high bicarbonates, and nitrates. However, it can be used for growing salt-tolerant crop such as mustard, and barley (Singh, 1999, Kahlown *et al*., 2009) by using suitable management practices. Continuous application of high SAR water for irrigation caused poor soil physical condition, reduced nutrient availability, poor microbial activity, and toxicity of certain ions which affected the productivity of soils. The organic matter status of sodic soils is extremely low, and thus major fraction of nutrient N required for crop growth in these soils must come from applied N fertilizers. Applied N, thus, with increasing sodicity mineralization is lowered and the gaseous losses are enhanced making the N unavailable to plants. In view of the above problems, efforts are aimed to find out ways, and means for utilizing such hazardous waters for managing sustainable crop production in the area which will subsequently lead to upliftment of standard of living of rural folks affected by the twin problems. The role of organic material in promoting reclamation of sodic soils through improvement of soil physical condition, greater mobilization of native Ca from $CaCO_3$ by organic acids, and increased partial pressure of CO_2 during its decomposition in soil resulting in turn, reduction in pH, and enhancement of biological activities is well known. All this can be achieved through use of technology, and inputs (Kanwar and Katyal, 1987). Apart from these characters, organic manures reduce the adverse effect of alkalinity, and decomposition products of organic materials form chelates which help in the nutrition of plants. Rajasthan state in India ranked first both in terms of area, and production by contributing about 50 % of the total rapeseed-mustard. It produced 3.82 million tonnes of rapeseed-mustard during 2013-14 (Oilseed Division, 2014). The area and production of rapeseed and mustard can be increased in the state of Rajasthan by scientific utilization of poor quality water (high SAR) for the irrigation in arid and semi-arid areas. Since, soils of the study zone are light in texture; possibilities have emerged that with suitable combination of inorganic fertilizer, and organic manure, this sodic water can be successfully used for mustard production. Present studies proved the hypothesis that poor quality water can be used for mustard production under sodic groundwater conditions in arid and semi-arid regions.

Materials and Methods

The experiments was conducted during *Rabi* season of the year 2012-13, and 2013-14 at Agronomy Farm, SKN College of Agriculture (SKNAU), Jobner (Rajasthan) India on loamy sand soil (Inceptisol) belonging to series Chomu (Typic Ustipasament) having pH 8.5. The electrical conductivity, CEC, and organic carbon content of soil were 2.57 dSm^{-1}, 6.87 Cmol (p+) kg^{-1} soil and 2.47 g kg^{-1} respectively. The fertility status of the experimental field was found to be low in available nitrogen (130.9 kg ha^{-1}), phosphorus (8.73 kg ha^{-1}), and medium in available potassium (128.7 kg ha^{-1}). The experiment was laid out in a split plot design with 24 treatment combination comprising of four levels of SAR water (SAR 6, 10, 20 and 30), and six nitrogen sources treatments (Control, 125% RDN* through urea, 75% RDN* through urea +50% RDN through FYM, 75% RDN* through urea +50% RDN through VC, 50% RDN* through urea +75% RDN through FYM, 50% RDN* through urea +75% RDN through VC) in three replications. Nitrogen was applied as per recommended dose of 60 kg N.The different levels of SAR were prepared by dissolving required quantities of NaCl, Na_2SO_4, $NaHCO_3$, $CaCl_2$ and $MgSO_4$ in base water of 6.0 SAR. The farmyard manure contained 16.3% total carbon, 0.55% N, 0.25% P, 0.51% K, and had a C:N ratio of 29.6, and vermicompost contained 18.0% total carbon, 1.50% N, 0.90% P, 1.07% K, and had a C:N ratio of 12.0. The organic materials as per treatments were applied 20 days before sowing. The processed soil samples (< 2 mm) were analyzed for pH, EC, organic carbon, and CEC by adopting standard procedures described by Jackson (1973). Seed and stover yield were recorded at harvest.

Microbial biomass C, N, and P were analysed following chloroform fumigation method, fifty g soil was fumigated for 24 h under vacuum in a vacuum desiccator using ethanol-free chloroform. Non-fumigated (50 g), and fumigated soils were extracted using 200 mL of 0.5 *M* K_2SO_4, and extracts were used for determining carbon (Vance *et al.* 1987), nitrogen (Brookes *et al.* 1985), and phosphorus (Brookes *et al.* 1982). Biomass C, N, and P were computed as: Soil microbial biomass C = Fc/0.45, where, Fc = organic carbon extracted by 0.5 *M* K_2SO_4 from fumigated soil - organic carbon extracted from non-fumigated soil.

Soil microbial biomass N = Fn / 0.68

where, Fn = (flush of mineral N in fumigated soilnon-fumigated soil)

Soil microbial biomass P = Pi /0.40

where, Pi = (amount of, inorganic P extracted from fumigated soil – non-fumigated soil)

Dehydrogenase activity was assayed by the method given by Casida *et al*. (1964). In the method, the soil samples were incubated with 2, 3, 5- triphenyl tetrazolium chloride (TTC) as electron accepter at 35^0C, and the production of triphenyl formazan (TPF) was measured on a spectrophotometer at 485nm, and the results are expressed in p kat triphenyl formazan (TPF) kg^{-1} soil [picokatol (p kat)] as one picomole of TTC hydrolysed or one p mole of TPF formed g^{-1} soil sec^{-1}. The assay of alkaline phosphatase was carried out according to the method of Tabatabai and Bremner (1969) with borax-NaOH buffer (pH 9.4) using *p*-nitrophenyl phosphate disodium salt as substrate at 35^0C.

Table 1: Effect of different sodic water and sources of N on oil content (%), oil yield (kg ha^{-1}) and protein content (%) in seed

Treatments	Oil content			Oil yield			Protein content		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Sodic water									
W_6 (6 SAR)	40.78	39.35	40.07	654.49	640.45	647.47	19.96	19.97	19.96
W_{10} (10 SAR)	40.02	38.89	39.45	540.65	559.32	549.98	20.17	20.19	20.18
W_{20} (20 SAR)	38.88	38.04	38.46	471.95	466.54	469.25	21.00	21.00	21.00
W_{30} (30 SAR)	36.94	35.84	36.39	361.77	355.03	358.40	21.62	21.53	21.57
SEm±	0.44	0.41	0.37	11.43	11.26	9.83	0.07	0.08	0.06
C.D.(P=0.05)	1.52	1.41	1.13	39.56	38.96	30.28	0.23	0.27	0.19
Sources of N									
M_0- control	37.38	36.31	36.85	306.37	306.05	306.21	19.47	19.61	19.54
M_1-125%RDN*(Urea)	38.01	36.86	37.44	361.81	390.27	376.04	20.06	20.05	20.05
M_2-75%RDN*(Urea)+50%RDN*(FYM)	38.75	37.62	38.19	478.99	473.68	476.33	20.60	20.50	20.55
M_3-75%RDN*(Urea)+50% RDN*(VC)	39.46	38.30	38.88	613.01	598.08	605.54	20.75	20.90	20.83
M_4-50%RDN*(Urea)+75%RDN*(FYM)	40.27	39.16	39.71	619.41	606.46	612.93	21.33	21.30	21.32
M_5-50%RDN*(Urea)+75%RDN*(VC)	41.05	39.92	40.48	663.72	657.48	660.60	21.90	21.66	21.78
SEm±	0.47	0.46	0.27	16.35	14.26	8.86	0.08	0.07	0.04
C.D. (P=0.05)	1.33	1.32	0.75	46.73	40.77	24.93	0.23	0.21	0.12

*RDN- Recommended dose of N, VC- Vermicompost

In order to test the significance of variation in experimental data obtained for various treatment effects, the data were statistically analysed as described by Fisher (1950). The critical differences were calculated to assess the significance of treatment mean wherever the 'F' test was found significant at 5 per cent level of probability. To assess inter-relationship between yield of mustard, and different soil properties, multiple regression equation were worked out. All these statistical estimates were done by standard procedure of Gomez and Gomez (1984).

Results and Discussions

Quality

Protein content in seed of mustard increased with increasing levels of SAR water (Table 1). According to Strogonov and Okinina (1961) as stated earlier, the N taken up by plants is not utilized, and gets accumulated in organs as protein, and not available for plant growth leading to increased content of N in seed which ultimately increased the protein content with increased levels of SAR water. The oil content and oil yield was also decreased significantly with the increasing levels of SAR water (Table 1). The decrease in oil content may be due to the adverse effect of alkalinity on the activity of enzymes responsible for the formation of oil in the seed. In alkaline conditions, excessive amount of salts have an adverse effect on soil enzyme activity as reported by Kaur *et al.* (2000). Singh *et al*. (2014) observed the reduction in oil yield of mustard due to application of saline irrigation water. The decrease in oil content in rape and mustard seed with increasing levels of sodic water was also reported by Ramdeo and Ruhal (1971), and Deo (1979) and in Palma rosa by Singh *et al.* (1994).

The data presented in Table 1 revealed that oil, and protein content in seed tended to increase with increasing levels of nitrogen sources during both the years as well as in pooled analysis. The increase in protein, and oil content under organic manure application can be assigned to the availability of all the essential nutrients which are present in organic matter, and their continuous mineralization (Survase *et al.*, 1986). Nitrogen is an essential constituent of protein, increase in N content led to higher protein content in seed. Increase in oil content might be due to the unique role of organic matter in improving the nutritional environment of rhizosphere via improvement in nutrient availability. Thus, the balanced nutrient uptake by plant owing to organic matter probably favoured enzymatic activities responsible for oil synthesis. The increase in oil yield was manifestation of increase in seed yield as well as its oil content due to applied organic manure. Dosani *et al.* (1999) also reported the higher protein, and oil content as well as oil yield of groundnut with 3 t ha^{-1} of poultry manure. These results are in close agreement with those of Sardana (1990), Mankotia and Sharma (1996), and Sukmal *et al.* (2004).

Yield

The seed and stover yield of mustard decreased significantly with increase in level of SAR in irrigation water during both the years, and in pooled data analysis (Table 2).This may be explained on the basis that increasing SAR in irrigation water increased the exchangeable sodium percentage, and pH of soil resulting into decreased availability of nutrients such as N, P, K, Ca, and Mg but increased the uptake of Na which is toxic to plant. The higher amount of Na may have adverse effects on physiological, metabolic, and enzymatic activities, and utilization of phosotynthates in plant. The cell elongation and cell division may also be adversely affected due to higher accumulation of Na. This may be a reason for decrease in seed, and stover yield of mustard. Further, the reduction in yield might also be the result of overall deleterious effect of Na on soil physical environment due to increase in bulk density, pH, ESP, and decrease in hydraulic conductivity of soil resulting into poor root development, and plant growth, and ultimately decreased yield of mustard. The existence of negative correlation between yield, and pH ($r = -0.833^{**}$), and SAR ($r=-0.749$) of soils also support the findings of present investigation (Table 4). Similarly, Pareek and Yadav (2011) also observed reduction in the seed, and stover yield of mustard with an increase in RSC of irrigation water.

Organic source of nitrogen substantially increased the seed and stover yield of mustard over control in both the years as well as in pooled analysis (Table 2). The increase in yield due to addition of organics may be the result of overall improvement

Table 2: Effect of different sodic water and sources of N on seed and stover yield (q ha^{-1}) of Indian mustard

Treatments	Seed yield			Stover yield		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Sodic water						
W_6 (6 SAR)	15.93	16.16	16.05	37.82	38.59	38.21
W_{10} (10 SAR)	13.46	14.34	13.90	33.61	34.57	34.09
W_{20} (20 SAR)	12.02	12.16	12.09	29.63	30.66	30.14
W_{30} (30 SAR)	9.70	9.82	9.76	26.12	27.07	26.60
SEm±	0.29	0.30	0.26	0.82	0.85	0.73
C.D.(P=0.05)	1.01	1.03	0.79	2.85	2.96	2.24
Sources of N						
M_0- control	8.16	8.40	8.28	24.44	25.39	24.92
M_1-125%RDN*(Urea)	9.43	10.53	9.98	26.11	26.73	26.42
M_2-75%RDN*(Urea)+50% RDN*(FYM)	12.22	12.45	12.33	29.98	31.20	30.59
M_3-75%RDN*(Urea)+50% RDN*(VC)	15.45	15.53	15.49	34.82	35.67	35.24
M_4-50%RDN*(Urea)+75%RDN*(FYM)	15.29	15.41	15.35	35.23	36.43	35.83
M_5-50%RDN*(Urea)+75%RDN*(VC)	16.12	16.42	16.27	40.21	40.92	40.56
SEm±	0.37	0.39	0.22	0.83	0.88	0.49
C.D. (P=0.05)	1.04	1.11	0.61	2.36	2.52	1.39

*RDN- Recommended dose of N, VC- Vermicompost

in soil physico-chemical properties of sodic soil due to decrease in bulk density, pH, ECe, SAR, and increase in saturated hydraulic conductivity, water retention ,cation exchange capacity, and organic carbon content as well as microbial biomass, and enzyme activities in soil (Pareek and Yadav, 2011; Jat *et al.*, 2012).These beneficial effects favoured greater availability of plant nutrients, and their steady supply throughout growth for optimum development. The higher nutrient availability, and congenial environment for their uptake, favoured greater synthesis of carbohydrates, and their efficient portioning into different sinks including reproductive structures which ultimately brought about significant improvement in seed yield. Application of M_5 (50% RDN* through urea + 75% RDN through Vermicompost) produced maximum pooled seed, and stover yield over control. The higher seed, and stover yield arising from different sources of nitrogen was further substantiated by the significant, and positive correlation(Table 4) of mean seed yield with organic carbon content of soil (r = 0.834**), microbial biomass C (r = 0.976**), N (r = 0.975**) and P (r = 0.978**), DHA (r= 0.965**), APA (r= 0.908**), and total N (r= 0.963**), P (r= 0.964**), and K (r= 0.962**). Results of the present investigation are in similar line with those of Bhat *et al.* (2007), Pareek and Yadav (2011), Wu *et al.* (2013), and Yaduvanshi (2015) who attempted to minimize the adverse effects of sodic irrigation water through different irrigation, soil, and crop management practices.

Interactive effect of SAR water, and different sources of water on seed yield was found significant during both the years and in pooled (Table 3).The data revealed that with each level of SAR, the yield increased significantly with the application of all the source of nitrogen during both the years, and in pooled

Table 3: interactive effect of different sodic water and sources of N on seed yield (q ha^{-1}) of Indian mustard

Treatments	W_6	W_{10}	W_{20}	W_{30}
2012-13				
M_0- control	11.20	8.83	7.27	5.33
M_1-125%RDN*(Urea)	12.70	10.17	8.53	6.33
M_2- 75% RDN* (Urea)+50% RDN*(FYM)	15.20	12.9	11.63	9.13
M_3-75 %RDN* (Urea)+50% RDN*(VC)	18.43	16.17	14.74	12.46
M4-50% RDN* (Urea)+50% RDN*(FYM)	18.30	15.87	14.87	12.13
M5-50% RDN* (Urea)+50% RDN*(VC)	19.77	16.8	15.1	12.8
SEm±				0.73
C.D. (P=0.05)				2.09
2013-14				
M_0- control	11.37	9.08	7.7	5.45
M_1-125%RDN*(Urea)	12.95	14.12	8.67	6.37
M_2- 75% RDN* (Urea)+50% RDN*(FYM)	15.42	13.3	11.85	9.23
M_3-75 %RDN* (Urea)+50% RDN*(VC)	18.65	16.33	14.78	12.33
M4-50% RDN* (Urea)+50% RDN*(FYM)	18.55	16.08	14.7	12.3
M5-50% RDN* (Urea)+50% RDN*(VC)	20.03	17.15	15.25	13.25
SEm±				0.78
C.D. (P=0.05)				2.22
Pooled				
M_0- control	11.28	8.96	7.48	5.39
M_1-125%RDN*(Urea)	12.83	12.14	8.6	6.35
M_2- 75% RDN* (Urea)+50% RDN*(FYM)	15.31	13.1	11.74	9.18
M_3-75 %RDN* (Urea)+50% RDN*(VC)	18.54	16.25	14.76	12.4
M4-50% RDN* (Urea)+50% RDN*(FYM)	18.43	15.98	14.78	12.22
M5-50% RDN* (Urea)+50% RDN*(VC)	19.9	16.98	15.18	13.03
SEm±				0.53
C.D. (P=0.05)				1.5

*RDN- Recommended dose of N, VC- Vermicompost

mean. Irrespective of all the sources of nitrogen, with increasing the levels of SAR of irrigation water gave significantly lower seed yield over lowest SAR level (W_6). Similarly, irrespective of SAR levels, the application of different sources of nitrogen significantly enhanced the seed yield of mustard over control. However, the interactive effect of M_3, and M_4 with each level of SAR was found at par to each other. The pooled data further indicated that the extent of increase in seed yield with the application of all the sources of nitrogen was less with higher levels of SAR as compared to lower levels. The magnitude of decrease in seed yield with increasing levels of SAR water was found less at application of the treatment of M_5 followed by M_3, and M_4. The reduction in pooled seed yield at $W_{30}M_0$ was 52.21 per cent, which decreased to 43.70, 22.87, per cent due to application of M_1, M_2, after that the adverse effect of SAR water was overcome due to increasing level of nitrogen sources, and after that yield increased by 9.92, 8.33, and 15.51 per cent with the application of M_3, M_4, and M_5, respectively at the same level of SAR water (W_{30}) over W_0M_0 (normal water + control).The maximum yield was recorded under application of W_0M_5 (normal water +50% RDN* through urea +75% RDN through VC), while minimum under $W_{30}M_0$ (30SAR + control) during both the years and in pooled analysis. It is evident from present investigation that the harmful effect of SAR rich water can be mitigated by applying organic sources of nitrogen instead sole application chemical fertilizer. This might be due to

Table 4: Correlation coefficient (r) between seed yield, and other soil properties (pooled mean)

Soil properties	Seed yield
C mic	0.976**
N mic	0.975**
P mic	0.978**
DHA	0.965**
APA	0.908**
Organic carbon	0.834**
Total N	0.963**
Total P	0.964**
total K	0.962**
pH	-0.883**
SAR	-0.749**
CEC	0.452*
Available Water	0.632**
SHC	0.655**

** Significant at 1% level of significance

the fact that, the high pH, and ESP of soil due to high SAR irrigation water reduced the availability of essential nutrients and organic carbon content in soil. Under such circumstances, the addition of organic manures increased the availability of nutrients to plants. The increased availability of nutrients, and congenial environment for their uptake due to favourable physicochemical properties of soil owing to addition of organic manure possibly resulted in greater extraction of nutrients from the soil by plant. The results of the present investigation are in agreement with those of Pareek and Yadav (2011) and Jat *et al*. (2012)

Conclusions

From the present investigation, it is observed that under irrigation with varying levels of SAR water, the protein content significantly increased; however, oil content, and oil yield in mustard seed decreased significantly. The application of 50% RDN through urea +75% RDN through VC (M_5) overcomes the adverse effects of SAR rich water on quality, and yield of mustard. Thus, keeping in view the above results, the farmers of the area having high sodic (SAR) water are advised to apply 50% RDN through urea, and 75% RDN through vermicompost for sustaining soil, and crop productivity.

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